# The Invasive Spotted Lanternfly:

A Brief Overview of Threat and Mitigation Concerns for Washington State

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**Introduction**

*Lycorma delicatula* (spotted lanternfly; SLF) is an invasive planthopper of the Fulgoridae family native to China, Taiwan, and Vietnam that is now established in North Korea, South Korea, and Japan as well as the Mid Atlantic United States[1]. First detected in Berks County, Pennsylvania in 2014, there are currently 130 counties throughout New York, New Jersey, Maryland, Connecticut, Ohio, Indiana, Virginia and West Virginia with spotted lanternfly infestations. 87 of these counties are under quarantine and the infestations are projected to continue across the continental US as well as potentially central and south America [2] if mitigation efforts are not taken[3]. Feeding on over 70 species of plants[4], including cultivated grapes, fruit trees, ornamentals, and timber, SLF poses a serious economic as well as ecological threat. Economic losses from SLF in Pennsylvania alone are estimated to be between $550 and $554 million since 2014[5]. Environmental losses are difficult to estimate as the SLF swarms host plants by the thousands in both adult and nymph stages, feeding on phloem and leaving hosts too debilitated to fight off pathogens, droughts, and hard winter conditions[6]. Additionally, the

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[1] Clifton, Eric H., Hajek, Ann E., Jenkins, Nina E., Roush, Richard T., Rost, John P., et al. 2020. Applications of Beauveria bassiana (Hypocreales: Cordycipitaceae) to Control Populations of Spotted Lanternfly (Hemiptera: Fulgoridae), in Semi-Natural Landscapes and on Grapevines. *Environmental Entomology*, *49 (4)*, 854-864. https://doi.org/10.1093/ee/nvaa064

[2] Jung, J.M., Jung, S., Byeon, D., Lee, W.H. 2017. Model-based prediction of potential distribution of the invasive insect pest, spotted lanternfly *Lycorma delicatula* (Hemiptera: Fulgoridae), by using CLIMEX. *Journal of Asia-Pacific Biodiversity, 10 (4)*, 532-538. https://doi.org/10.1016/j.japb.2017.07.001.

[3] Ladin., Zachary S., Eggen, Donald A., Trammell, Tara L.E., D'Amico, Vincent. 2023. Human-mediated dispersal drives the spread of the spotted lanternfly (*Lycorma delicatula*). *Scientific Reports, (2023) 13:1098*. https://doi.org/10.1038/s41598-022-25989-3

[4] Aviles-Rosa, Edgar O., Nita, Mizuho, Feuerbacher, Erica, Hall, Nathaniel J. 2022. An evaluation of Spotted Lanternfly (*Lycorma delicatula*) detection dog training and performance. *Applied Animal Behaviour Science, 258, (2023) 105816*. https://doi.org/10.1016/j.applanim.2022.105816

[5] Ladin, Eggen, Trammell, et al.

[6] Aviles-Rosa, Nita, Feuerbacher, et al.

accumulation of SLF excrement (honeydew) on host plants promotes the growth of sooty mold, attracts other insects, and ultimately blocks photosynthesis[7]. Standard SLF mitigation consists primarily of the use of pesticides and sticky traps both of which impact non-target insects; the latter ensnaring small vertebrates such as birds, and contributing to waste as the glue is non-recyclable[8].

**Dispersal**

In acknowledgment of the established and expanding presence of the SLF throughout the Mid Atlantic US, it should also be acknowledged that in addition to the abundance of potential native and non-native host plants, the climate of that region is favorable for SLF. According to the National Oceanic and Atmospheric Administration's National Centers for Environmental Information (NOAA, NCEI) , much of the Northeast and Mid Atlantic are experiencing average temperatures of "much above average" with known infested states New Jersey and Connecticut experiencing their warmest January on record[9]. A 2019 study by the Departments of Biosystems Machinery Engineering and Applied Biology at Chungnam National University in Daejeon South Korea using the CLIMEX model to predict future distribution of SLF suggests both that rising temperatures promotes the spread of SLF and that increased precipitation might be unfavorable for SLF[10]. Additionally NOAA reported that as of January 2023, approximately

[7] Ibid.
[8] Urban, Julie M., Calvin, Dennis, and Hills-Stevenson, Jillian. 2021. Early Response (2018-2020) to the Threat of Spotted Lanternfly, *Lycorma delicatula* (Hemiptera: Fulgoridae) in Pennsylvania. *Annals of the Entomological Society of America, 114 (6)*, 709-718. https://doi.org/10.1093/aesa/saab030
[9] "January 2023 National Climate Report." *National Oceanic and Atmospheric Administration*, Feb. 2023. https://www.ncei.noaa.gov/access/monitoring/monthly-report/national/202301
[10] Byeon, Dae-hyeon, Jung, Jae-Min, Jung, Sunghoon, Lee, Wang-Hee. 2019. Effects of types of meteorological data on species distribution predicted by the CLIMEX model using an example of *Lycorma delicatula* (Hemiptera: Fulgoridae). *Journal of Asia-Pacific Biodiversity, 13, (2020) 1-6.* https://doi.org/10.1016/j.japb.2019.11.010

42.7% of the contiguous US was in drought and that drought or abnormally dry conditions had expanded across portions of the southern Plains, Florida Peninsula, Rockies, Midwest, and Pacific Northwest[11]. If continued, these trends will exacerbate the expansion of SLF into new US territories.

The spread of SLF is being accelerated not just by climate and the wide range of available host plants across the US, but also by SLF's ability to deposit egg masses on inanimate surfaces such as rocks, metal, and wood[12] which can overwinter freezing conditions[13]. Human mediated dispersal via east-to-west traffic via train routes, roads, and highways lined with SLF's preferred host, the widespread, invasive *Ailanthus altissima* (tree of heaven; TOH) is expected to be the primary driver of SLF's westward expansion[14]. Though no reported sightings of SLF in the state of Washington have been confirmed, the Washington State Department of Agriculture (WSDA) has included SLF on their website to alert Washingtonians to the threat they pose to numerous WA crops, including: almonds, apples, cherries, grapes, hops, maple trees, nectarines, oak trees, peaches, pine trees, plums, poplar trees, sycamore trees, walnut trees, and willow trees[15]. With WA ranking among the top wine and hops producing states in the country, earning an annual gross income of over $8 billion from wine[16] alone, it is vital to develop SLF detection and mitigation plans at both a state and community level.

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[11] "January 2023 National Climate Report." *National Oceanic and Atmospheric Administration*
[12] Ladin, Eggen, Trammell, et al.
[13] Shim, Jae-Kyoung, Lee, Kyeong-Yeoll. 2015. Molecular characterization of heat shock protein 70 cognate cDNA and its upregulation after diapause termination in *Lycorma delicatula* eggs. *Journal of Asia-Pacific Entomology, 18*, 709-714. https://dx.doi.org/10.1016/j.aspen.2015.08.005
[14] Ladin, Eggen, Trammell, et al.
[15] "What is Spotted Lanternfly?" *Washington State Department of Agriculture*, 2023. https://agr.wa.gov/departments/insects-pests-and-weeds/insects/spotted-lanternfly
[16] "Fast Facts." *Washington State Wine Commission,* 2023. https://www.washingtonwine.org/fast-facts/#:~:text=Washington%20is%20the%20second%2Dlargest,annual%20in%2Dstate%20economic%20impact

**Detection: Findings and Recommendations**

While WSDA provides inspection services to facilitate the safe transport of commercial agriculture, there are currently no agricultural checkpoints (like those in California) to screen non-commercial vehicles for potential invasive hitchhikers. This leaves WA vulnerable to the smaller concentrations of SLF egg masses and adult hitchhikers that would be liable to travel via private traffic from infested states in the late summer months when SLF females may be gravid or have deposited their egg masses on vehicles or cargo. As the SLF changes appearance drastically over their life-cycle, it may be challenging for the public to properly identify them. Coordinated public messaging spanning all contiguous US states must not only stress the potentially disastrous effects of SLF, but also provide clear visual guides for how to spot them in all stages.

According to a novel study performed by the Animal and Food Sciences Department of Texas Tech University, dogs may play a critical role in halting the further spread of SLF. Researchers at their Canine olfaction research and education (CORE) lab analyzed the efficacy of ten individual canines of varied sex, breed, and age with previous olfactory detection training to detect the odor of dead SLF egg masses, and found that after roughly 20 training sessions, all ten test subjects were able to detect SLF egg masses with a success rate of 99%[17]. Considering that SLF egg masses are often deposited underneath protective layers such as bark and covered with a waxy substance that both protects and camouflages, SLF egg masses are exceedingly difficult to spot with the naked eye. The employment of specially trained SLF-sniffing-dogs may

[17] Aviles-Rosa, Nita, Feuerbacher, et al.

ultimately prove to be one of the most effective and efficient detection tools available, and investment in this training for use at commercial checkpoints should be prioritized.

**Mitigation: Findings and Recommendations**

Whereas SLF detection relies primarily on monitoring traffic from infested areas, public awareness, and ideally, as recommended above, utilizing specially trained canines, mitigation once an infestation has begun proves much more challenging. This is in large part due to the prevalence of a broad spectrum of potential host plants in addition to the high rate of SLF reproduction, as each individual egg mass typically contains 30 - 50 eggs[18]. For these reasons, it is important to consider a wide array of factors when planning SLF mitigation strategies.

**Attractants & Lures**

Once introduced, the SLF multiplies at an exponential rate necessitating aggressive eradication measures at every stage of their life cycle. Recent studies into the development of lures and attractants present compelling findings regarding SLF's sensitivity to sound, light, and chemical compounds present in host plants. In a study published by the Entomological Society of America in 2018, the volatile methyl salicylate (abundant in TOH) was found to be highly attractive to SLF at all stages of its lifecycle, increasing trap efficacy by a factor of 2-4 in the field when used as a lure[19]. The research into other effective plant volatiles is ongoing and will likely be an important aspect of designing effective traps.

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[18] Ibid.

[19] Cooperband, Miriam F., Wickham, Jacob, Cleary, Kaitlin, Spichiger, Sven-Erik, Zhang, Langwa, et al. 2019. Discovery of Three Kairomines in Relation to Trap and Lure Development for Spotted Lanternfly (Hemiptera: Fulgoridae). *Journal of Economic Entomology, 112 (2)*, 671-682. https://doi.org/10.1093/jee/toy412

Additionally, as it is known that other species of Hemiptera communicate through vibrations in their substrate, the United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) supported a study that tested the hypothesis that SLF would respond to vibroacoustic stimuli and found that both adult and nymph SLF were attracted to a 60-Hz signal broadcast into their test substrate[20]. Vibrational communication in insects is also a key factor in their copulatory habits, and this study suggests that utilizing sound could be harnessed not only to aggregate large quantities of SLF, but also to potentially disrupt their mating habits[21].

Exploring the combinations of effective plant volatiles and vibroacoustic attractants in places suffering acute SLF infestation may greatly increase the efficacy of employed traps. Furthermore, SLF are susceptible to ecological traps such as tall buildings and telephone poles that they confuse for a potential host, exhaust themselves canvassing for phloem, and eventually starve[22]. Pairing existing infrastructure with other lure techniques in a strategic fashion could be a cost-effective way to combat SLF in developed areas.

**Biocontrol**

Because there is still much to understand about natural predation of the SLF, research into native predators will be needed in each new region SLF expands to. However, early observation

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[20] Rhode, Barukh B., Cooperband, Miriam F., Canlas, Isaiah, Mankin, Richard W. 2022. Evidence of Receptivity to Vibroacoustic Stimuli in the Spotted Lanternfly *Lycorma delicatula* (Hemiptera: Fulgoridae). *Journal of Economic Entomology, 115 (6)*, 2116-2120. https://doi.org/10.1093/jee/toac167

[21] Ibid.

[22] Frank, Kenneth D., Cowper, Gregory W. 2022. Skyscrapers as Ecological Traps of the Spotted Lanternfly (*Lycorma delicatula*) (Hemiptera: Fulgoridae): Preliminary Observations. *Entomological News, 130 (3)*, 232-244. https://doi.org/10.3157/021.130.0303

of SLF predation in Berks County, Pennsylvania suggests that some native predatory insects will prey upon SLF as a readily available food source. A Pennsylvania Department of Agriculture field crew observed a predatory stink bug, *Apoecilus cynicus*, attacking an SLF, releasing the SLF during specimen collection, and resuming feeding after being left undisturbed for a period of time[23]. Similarly, a wheel bug, *Arilus cristatus*, was documented feeding on an SLF in Berks County, 2015[24]. Both species of predatory Hemiptera have a broad distribution throughout North America, ranging as far west as Arizona. Although these findings are encouraging, authors of the American Entomological Society paper in which they were published, Lawrence E. Barringer and Erica Smyers, also point out that both naturally occurring specialist parasitoids for planthoppers and predation by generalist predators and birds have not been observed, likely due to cytotoxins SLF acquire feeding on TOH[25]. Fortunately, since the publication of Barringer and Smyers' findings, other generalist arthropod predators including the Chinese mantis (*Tenodera sinensis*), various spiders, and vespid wasps have also been observed feeding on SLF[26].

Potentially introducing two non-native species from China, an egg parasitoid *Anastatus orientalis*, and a nymphal parasitoid, *Dryinus sinicus*, as biocontrol agents was suggested in a 2020 study published by the Entomological Society of America[27], though more research into the lab rearing and mass stockpiling techniques of both species needs to be completed before

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[23] Barringer, Lawrence E., Smyers, Erica. 2016. Predation of the Spotted Lanternfly, *Lycorma delicatula* (White) (Hemiptera: Fulgoridae) by Two Native Hemiptera. *Entomological News, 126 (1)*, 71-73. https://doi.org/10.3157/021.126.0109

[24] Ibid.

[25] Ibid.

[26] Clifton, Hajek, Jenkins, et al.

[27] Broadley, Hannah J., Gould, Juli R., Sullivan, Liam T., Wang, Xiao-Yi, Hoelmer, Kim A., et al. 2020. Life History and Rearing of *Anastatus orientalis* (Hymenoptera: Eupelmidae), an Egg Parasitoid of the Spotted Lanternfly (Hemiptera: Fulgoridae). *Environmental Entomology, 50 (1)*, 28-35. https://doi.org/10.1093/ee/nvaa124

deployment. Additionally, the environmental impact of these non-native parasitoids on infested US ecosystems should be thoroughly studied and carefully considered before introducing new invasives.

**Traps and Insecticides**

From the onset of SLF's introduction in Pennsylvania, adhesive traps and insecticides have been the standard protocol for SLF management. After emergence, SLF nymphs climb the trunks of host trees to feed and can be ensnared by glue-coated bands baited with host volatiles[28]. These traps exhibit diminished efficacy as the SLF passes from nymph stage to third and fourth instar phase to adulthood, as they become able to pull themselves off the adhesive or avoid walking on it altogether[29]. Furthermore, adhesive traps become clogged with debris and catch non-target insects and birds, requiring regular upkeep to remain safe and effective. Although there are several designs of adhesive SLF traps currently available, placement and maintenance of every trap is critical to their efficacy, and no one trap has been found to reliably catch SLF in every phase of its lifecycle. Furthermore, SLF has been documented to utilize the shelter provided underneath adhesive bands to deposit egg masses on the bark beneath[30]. Considering that as well as how labor-intensive and wasteful these traps are, in order to prevent bycatch of larger vertebrates, it is recommended that guards constructed of chicken wire are installed around each trap. For these reasons, adhesive SLF traps may very well do more harm than good, and the

[28] Fancese, Joseph A., Cooperband Miriam F., Murman, Kelly M., Cannon, Stefani L., Booth, Everett G., et al. 2019. Developing Traps for the Spotted Lanternfly, *Lycorma delicatula* (Hemiptera: Fulgoridae). *Environmental Entomology, 49 (2)*, 269-276. https://doi.org/10.1093/ee/nvz166
[29] Ibid.
[30] Ibid.

repercussions of their usage should be seriously considered before employing them as a primary defense against SLF.

Although common insecticides have been used against SLF, they are problematic as they will also kill beneficial insects and pollinators. Additionally, due to the high number of potential host plants, broad scale application of residual contact spray insecticide is required to be effective against SLF nymphs[31], and compounds the risk of damaging populations of beneficial native species. For these reasons, research published by Entomological Society of America suggests that specially targeted mycoinsecticides derived from fungal entomopathogens such as *Beauveria bassiana* and *Batkoa major* (commercially formulated as Aprehend and BoteGHA) may be the best way to combat high-density populations of SLF in commercial, semi-natural environments such as vineyards and tree farms with minimal risk to non-target species[32].

**Discussion**

In order to prevent what by all accounts appears to be the inevitable expansion of SLF throughout the US, it will take a concerted effort across state departments to implement the appropriate combination of aforementioned mitigation techniques in addition to aggressive public messaging about SLF identification, potential threat concerns, and human dispersal awareness. Continuing to prioritize funding the research and development of further refined detection and eradication measures will be a vital component as well. Although building new infrastructure to enable more regular agricultural checkpoints on US throughways crossing state lines may be too costly and obtrusive for many states and their citizens, the benefits therein

[31] Windall, Terry. How to Combat the Spotted Lanternfly Now in the Nymph Stage in Pennsylvania. *Massachusetts Newswire*, *June 22, 2020*, p. NA.
[32] Clifton, Hajek, Jenkins, et al.

should be considered. Infrastructure projects are known to create jobs, and mounting this particular effort could employ dogs as well as people, not to mention lending preparedness for other rapid-spreading invasives like SLF. Though this species of pest is novel to the US, much can be learned from its earlier expansion into Korea and Japan, and cooperative efforts to pool resources against the further spread of SLF should be encouraged in every possible way.

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